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Instruction Manual

Model 215

NON-OVERLOADING AMPLIFIER

Baird-Atomic, Inc.
Cambridge, Mass. USA

Instruction Manual

Model 215

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Baird-Atomic, Inc.

33 University Road, Cambridge 38, Massachusetts

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SECTION 1
GENERAL DESCRIPTION

1-1. PURPOSE

The Model 215 Amplifier is a linear pulse amplifier for use in precision scintillation counting. It is capable of fast recovery after severe overload and can faithfully amplify small pulses in the presence of very large and frequent overload pulses. This feature makes it particularly useful for pulse height analysis of X-rays in the presence of high energy gamma rays. In addition to the amplifier, the Model 215 also incorporates an integral discriminator circuit.

1-2. SPECIAL DESIGN FEATURES

For stable, linear, non-overloading response, the following design features are included:

(1) Feedback loops: The three amplifier loops are essentially similar, incorporating some of the design features of both the "Oak Ridge-Fairstein" and the "Brookhaven-Chase" design. Feedback is applied in each amplification stage to the cathode of the first tube.

(2) To preserve linearity, positive feedback through the "boot-strap" method is employed.

(3) Non-overloading features: Overloading in the usual sense of the word refers to the non-linear effects caused by large input signals. In particular, the charging of grid coupling capacitors, owing to grid current, introduces disturbing after-effects. The design of a non-overloading amplifier introduces non-linearities by limiting the size of a pulse deliberately and in such a way that the transition to the normal, linear mode of operation can begin immediately after the overload signal ceases.

Four types of non-overload techniques are used:

(a) "Difference" amplification cuts gain when large pulses arrive.
(b) Limitation of maximum input (V105, V106A, V109).
(c) D.C. coupling to avoid charging of coupling capacitors (V101B, V103B).
(d) Use of small grid resistors so that grid current does not change input time constant appreciably (V106A, V108).

1-3. BRIEF PRINCIPLE OF OPERATION (See Block Diagram, Fig. 4-1)

The incoming signal is shaped by the input RC network, part of which is the COARSE GAIN control. The first feedback amplifier amplifies the signal twenty-eight times. The signal then passes the FINE GAIN control. The second stage of amplification (i.e., the output of V104B) has a gain of twenty-two. The adder circuit (V105A and B) accomplishes the second differentiation of the pulse. The next stage is another negative feedback amplifier with a gain of fifty, employing internal positive feedback to insure linear outputs. The maximum positive signal excursion is limited to 110 volts by a double diode

clamp, V110. The output stage is essentially a feedback amplifier; the output, however, is taken from the cathode of the first tube, V110.

An alternative output from the integral discriminator produces negative pulses of fixed amplitude. Hence the output from the discriminator will merely indicate the presence or absence of pulses of a certain amplitude.

1-4. OPERATING SPECIFICATIONS

Primary Power: 115 V, 50-60 cycles, at 1.8 amps.

Input: 500 μsec (decay time) negative polarity

Output:

HIGH OUT: Maximum output 110V positive polarity from cathode of V110 pulse shape as sketched in Figure 4-1, impedance 30 ohms.

LOW OUT: Fixed proportion of High Out (1/30), output impedance 300 ohms.

PHS OUT: Output from pulse height discriminator, 60V negative polarity, impedance 3300 ohms.

Input Impedance: 1600 ohms

Gain: Maximum 6,400; minimum 72

Linearity: 0.5%

Rise Time: 0.2 microseconds

Noise: White (random) noise at maximum gain, 0.5V rms; 60 cps ripple at maximum gain, 0.5V rms.

Gain Stability: Any change of line voltage in the range from 95V to 130V affects the gain by less than 0.5%.

Overload Test: For large signals the design of the amplifier provides limiting in five of its stages. The recovery time is proportional to the logarithm of the input pulse height and is about 40 microseconds for 1000 time overload ("1000 time overload" refers to an input signal 1000 times larger than one which gives full output). Owing to this feature, the amplifier does not introduce any base line distortion after recovery, even under overload conditions.

Reliability: As a rule derating of tubes (i.e., operating at half emission and half power) and derating (of power rating) of resistors was applied.

1-5. CONTROLS

POWER SWITCH: DPDT

COARSE GAIN: Six-position rotary switch indicating relative amplitudes. Steps are: 64, 32, 16, 8, 4, 2.

FINE GAIN: Continuous control, varying the relative output from 100% to about 37%.

PULSE HEIGHT SELECTOR: Sets the threshold of the integral discriminator. Range (0-100V) referred to the amplifier output.

1-6. EXTERNAL CONNECTORS (all mounted in the rear)

INPUT: BNC (JK-36)

PRE-AMPLIFIER POWER: AN3102-16S-1S (JK-31)

HIGH OUT: Cathode of V110, maximum output 110V, positive polarity, pulse shape as sketched in Figure 4-4 impedance 30 ohms (or by-passing R170, 10 ohms).

LOW OUT: Fixed ratio of HIGH OUT: 1/30; output impedance 300 ohms.

PHS OUT: Output from pulse height discriminator, 60V negative, 0.7 microsecond duration, impedance 3300 ohms.

1-7. PHYSICAL SPECIFICATIONS

Dimensions: 8 3/4" x 19" standard rack mount extending 14" behind panel (including receptacles).

Weight: 45 pounds

Finish: Gray lacquer, white and black screening; steel chassis cadmium plated with irridite dip.

Tube and Indicator Lamp Complement:

1 - OD3
1 - 5U4GA
1 - 6AC7
4 - 6AK5
1 - 6AL5
5 - 6AU8
1 - 6BZ7
1 - 85A2
1 - 6080
5 - 6197/6CL6
1 - NE51

SECTION 2
INSTALLATION

2-1. GENERAL

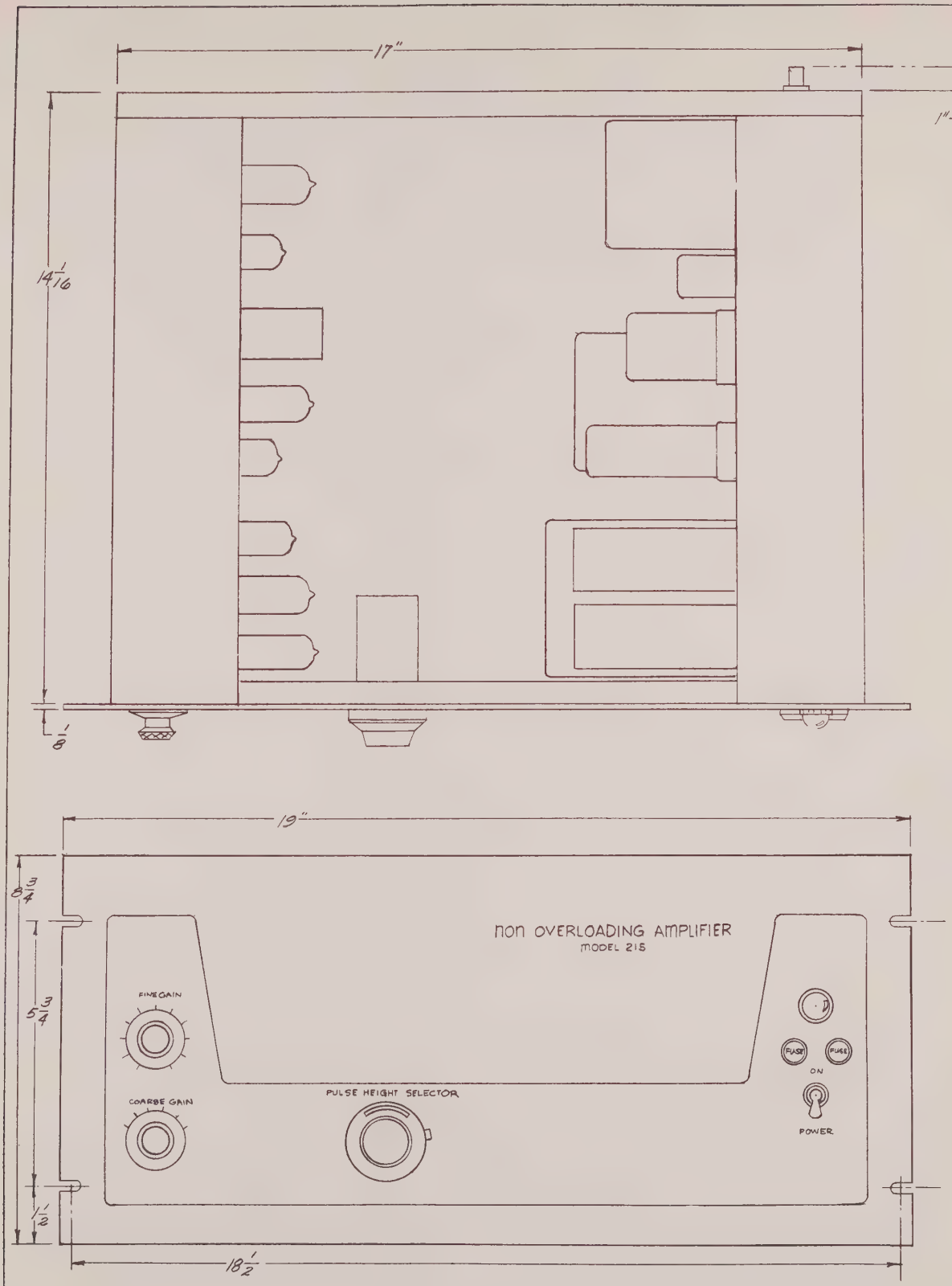
It is recommended that Section 1, General Description be studied for general information before installation. The outline drawing (Fig. 2-1) supplied in this section will be useful in planning an installation.

2-2. LOCATION

The equipment is self-contained. It may either be used in its own cabinet placed on a bench or table, or it may be removed and mounted in a relay rack. No side access is required. Therefore, it can be placed next to a wall or between other units. There should be a back clearance behind the equipment sufficient to make connections and provide adequate ventilation.

2-3. PRECAUTIONS

Caution should be taken when installing the equipment to avoid damaging the delay line which is mounted on the back. If the preamp power plug is to be mounted and used, room should be left for it.



OUTLINE AND MOUNTING DIMENSIONS
MODEL 215

FIGURE 2-1

SECTION 3
OPERATION

3-1. Operating Controls: See 1-5, 1-6 for description of their function.

3-2. Auxiliary Equipment: The two normal installations of the Model 215 with auxiliary equipment are shown in the accompanying block diagrams (Fig. 3-1). As indicated in the diagrams, the upper installation is used for differential analysis, and the lower for integral analysis.

3-3. Typical Operational Procedures: Operation of the 215 is best understood by describing its use in specific applications. Therefore, two typical uses, employing Baird-Atomic equipment, will be described. From these examples, operation of the 215 in other applications should be obvious.

To obtain an integral curve, assemble the equipment indicated in the block diagram and make the following connections. Connect signal cable of radiation detector (e.g., Baird-Atomic Model 810) to the preamp input connector on the 215, J102. (If the preamp does not require an external source of B+, connect to J101.) Be certain that the detector has low output impedance and that its signal is of the proper polarity and shape, as indicated on the block diagram. If the detector requires an external source of high voltage, be certain that this connection has been made. Connect PULSE HEIGHT OUT jack of the 215, J105, to the scaler input jack (e.g., Baird-Atomic Model 131). Switch all power switches to ON and allow at least 30 seconds for tubes to reach operating temperatures. Set both COARSE and FINE GAIN controls completely counterclockwise. Place radioactive sample in position for detection (in this case, Cs^{137}), and choose a setting of the PULSE HEIGHT SELECTOR which will allow amplification of the complete spectrum (e.g., a reading of 670 for this sample). This setting can be easily discovered by checking the characteristic energy spectrum of the sample. Increase COARSE GAIN slowly until a low counting rate increases very rapidly. Reset scalers to zero, switch to CLOCK, set clock for desired counting time (e.g., one minute for the accompanying curve), set PULSE HEIGHT SELECTOR to read 050, and note counting total. Similarly, take counts at successively higher readings of the PHS (e.g., 5V intervals except at critical places where closer intervals were used). A curve of the accompanying type (Fig. 3-2) will result from such a procedure.

To obtain a differential curve, assemble the equipment indicated in the block diagram and make the following connections. For connection at the radiation detector to the 215, note the instructions in the previous paragraph. Connect the HIGH OUT connector, J104, to the INPUT of the pulse height analyzer (e.g., Baird-Atomic Model 510). The LOW OUT connector, J103, may be used for monitoring with an oscilloscope. The OUTPUT jack of the analyzer should be connected to the scaler (e.g., Baird-Atomic Model 131). Switch all power switches to ON and allow at least 30 seconds for tubes to reach operating temperatures. Proceed as with integral curve in preceding paragraph to ascertain proper setting for COARSE and FINE GAIN controls, in this case shifting the BASE LINE control to permit optimum spectrum as

ascertained from characteristic energy levels of the sample. (In the case of unknown samples, consult instruction book of pulse height analyzer for proper procedure.) Choose setting of Channel Width control in the same fashion. Proceed as in above paragraph to plot the curve of the counting totals. For a sample of Cs^{137} with Baird-Atomic Model 810 Detector, 215 Amplifier, 510 Pulse Height Analyzer, and 131 Scaler, the accompanying differential spectrum was taken (Fig. 3-2).

a. Alignment: These adjustments are set at the factory and should only be changed by someone fully familiar with the principle of pulse shaping used in the 215 (as described in the Appendix).

b. Balance Adjustment: Adjust the potentiometer, R214, for optimum balance (minimum low frequency components) as seen on an oscilloscope at the output.

c. Overshoot Adjustment: Adjust C126 for maximum rise time without overshoot as seen on an oscilloscope at the output.

d. Discriminator Zero: For proper setting of Discriminator Zero Adjust, R188, attach some indicating device (scaler or oscilloscope) to the PHS OUT of the 215. Feed fixed pulses to J101 of sufficient amplitude to produce a signal with COARSE GAIN set at 64 and PHS set at 100. Keeping pulser constant, change COARSE GAIN to 32, PHS to 50. If there is no signal, turn R188 (screwdriver adjustment of bias of V118) until a signal appears. Repeat procedure at COARSE GAIN 16, PHS 25, and at 8-12.5 etc. up and down the scale until a signal appears at all these readings.

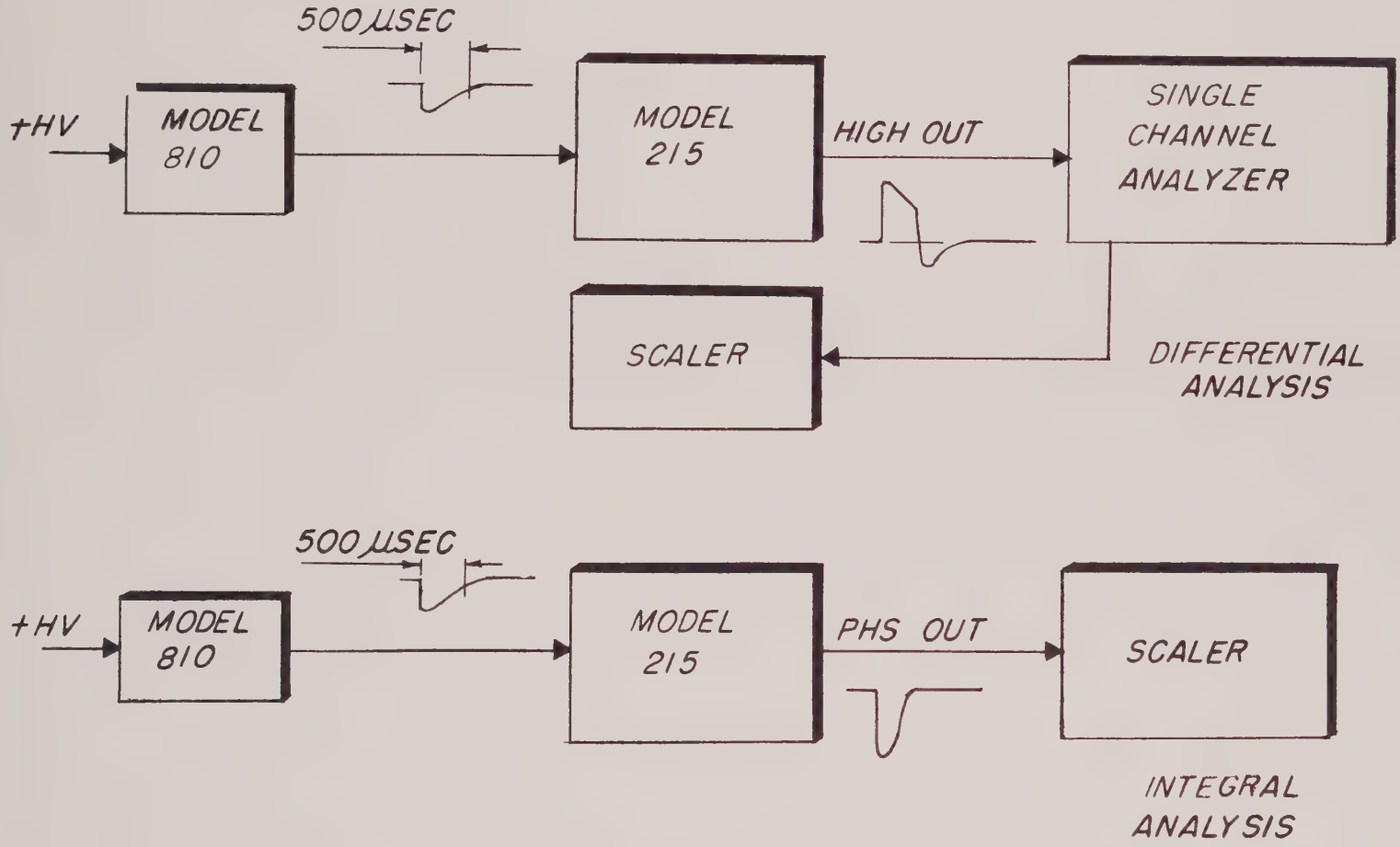


FIGURE 3-1
SYSTEM CONNECTIONS
FOR
SCINTILLATION PULSE HEIGHT ANALYSIS

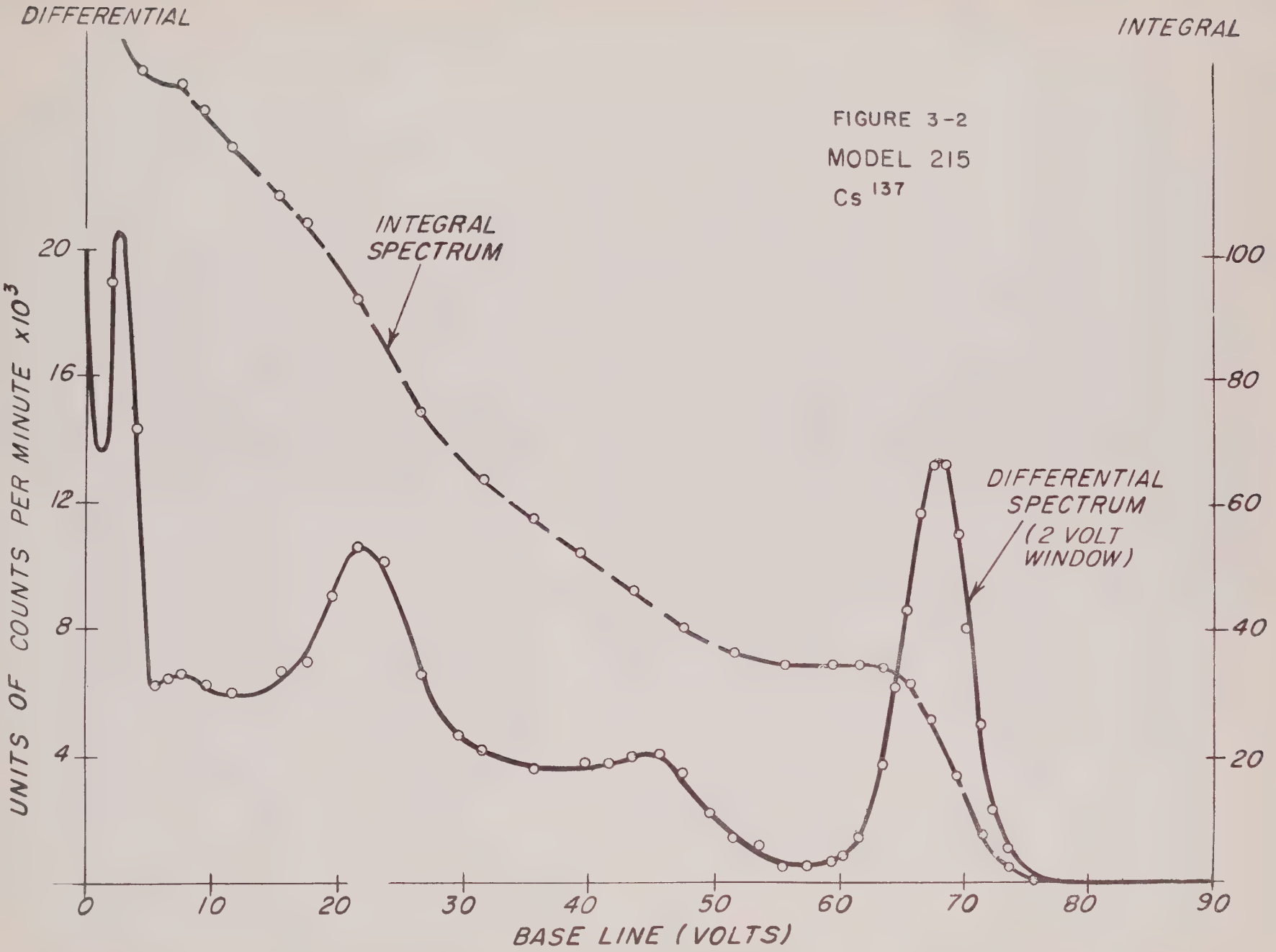


FIGURE 3-2
MODEL 215
Cs^{137}

SECTION 4
THEORY OF OPERATION

NOTE: For detailed theory of pulse-shaping in the 215, see Appendix 'A'.

4-1. FIRST PULSE-SHAPING (See Fig. 4-1)

The Model 215 Amplifier obtains optimum pulse-shape through two separate shaping ("differentiating") processes. In the first of these, the input signal, which should have a decay time-constant of at least 200 microseconds, is differentiated by the input RC network, part of which is the COARSE GAIN control. This network with a short time constant of 1.6 microseconds prevents a "pile-up" of small pulses which could affect the grid bias of the first and later stages.

4-2. FIRST STAGE OF AMPLIFICATION (See Fig. 4-2)

The negative input signal is amplified through V101A and appears as a positive signal at the grid of V101B. V101B and V102A are connected as a difference amplifier with their grids coupled through a long time constant (R115 and C104). Under normal conditions, i.e., when the positive input signal at the grid of V101B is small, the difference amplifier can operate with low effective cathode impedance since both V101B and V102A are conducting. When the signal is large, V102A cuts off and all current flows through V101B, the effective cathode impedance of which is now R116 (13K). For large signals V101B will draw grid current; but since there is no coupling capacitor in the grid circuit, it will return to its quiescent operating point as soon as the large signal ceases. However, direct coupling to V102B is unnecessary since it will normally have negative signals and, therefore, draw no grid current. Thus conventional RC coupling is possible.

Two feedback loops help to stabilize the gain characteristics of the first stage. High frequency negative feedback is applied from the cathode of V102B to the cathode of V101A. There is also a second, low-frequency feedback loop: from the cathodes of V101B and 102A via R113 and R107 to the grid of V101A (Fig. 4-3). By this means, low frequency fluctuations in voltage (caused, for example by changes in tube characteristics) are stabilized. The long time constant of R112 and C101 confines the effectiveness of this feedback to the quiescent current conditions of V101A and the difference amplifier.

4-3. SECOND STAGE OF AMPLIFICATION

This stage is very similar to the first one, except that V104B has as plate load the delay line and its impedance matching resistor, R132.

4-4. SECOND PULSE SHAPING AND AMPLIFICATION: The "ADDER" Circuit (See Fig. 4-4)

The grids of V105 are biased to about 14V to secure cathode degeneration. One grid receives a portion of the negative output of the second stage, and the other grid receives a signal of equal magnitude and opposite polarity, but delayed one microsecond

by the delay line. By means of a common plate current these two signals are added algebraically. The result (see table of waveforms, Fig. 4-4) is a positive signal of about one microsecond duration, followed by a negative signal of exponential decay. Note that the adder circuit has a gain of one since the effective plate load is 4.7K (R143) in parallel with 5.1K (R146).

4-5. FOURTH STAGE OF AMPLIFICATION (See Fig. 4-5)

The fourth stage is a feedback amplifier with an over-all gain of fifty. The gain of V106A is diminished by the small grid resistor in parallel with the plate load. (It will be recalled that the input time constants must be small to minimize the effects of grid current on the bias of the tube.) This stage has the usual negative feedback, but also employs positive feedback (from the cathode of V109 to the plate of V108 through C123) in order to increase the linearity for large signals. The positive excursions of V108 are limited by the clamping diodes V107 which conduct when the plate of V108 exceeds 240V. It limits the amount of positive signal reaching V109, again controlling the effects of grid current. The large choke, L103, keeps the current drain from the B+ supply essentially constant and reduces the current requirement for the next stage.

4-6. OUTPUT STAGE

The Output Stage must decouple the output load from the sensitive feedback cathode of V109 and supply enough current (50 ma peak) for external loads up to 2K. For this purpose a feedback amplifier is used with the output taken from the cathode of V110, making this stage an elaborate version of the "stacked" cathode follower circuit. V111, a power pentode, feeds back to the cathode of V110, greatly increasing the power output of this stage.

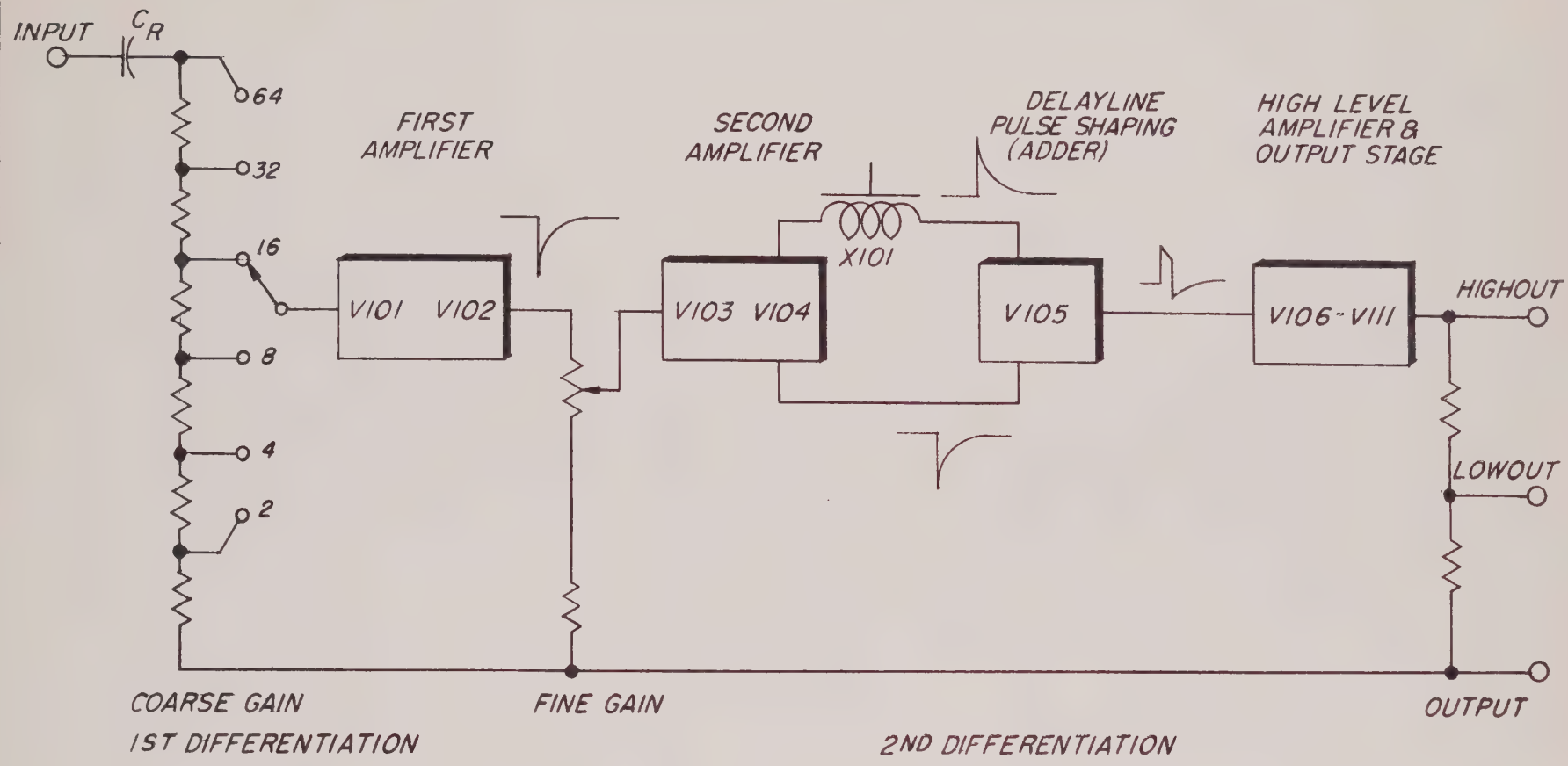
4-7. PULSE HEIGHT DISCRIMINATOR (See Fig. 4-6)

The output pulses of the amplifier are applied to the difference amplifier composed of V117 and V118. The grid of V118 is held fixed at 100V, whereas the grid of V117 is biased to cut off. When a positive signal overrides the bias, V117 conducts and the resultant increase in the cathode voltage of V118 cuts it off. This pulse is then applied to a Schmitt trigger circuit, V119 and V120. V119 is normally conducting so that sharp break-away is achieved with negative input pulses. V120, the second half of the Schmitt circuit, is normally cut off. The positive pulse through C142 triggers the output pentode, V121, which is normally cut off by the large cathode resistor (R204). Since the coupling time constant (C142 and R203) is short, the output pulse from the discriminator is a fast negative pulse.

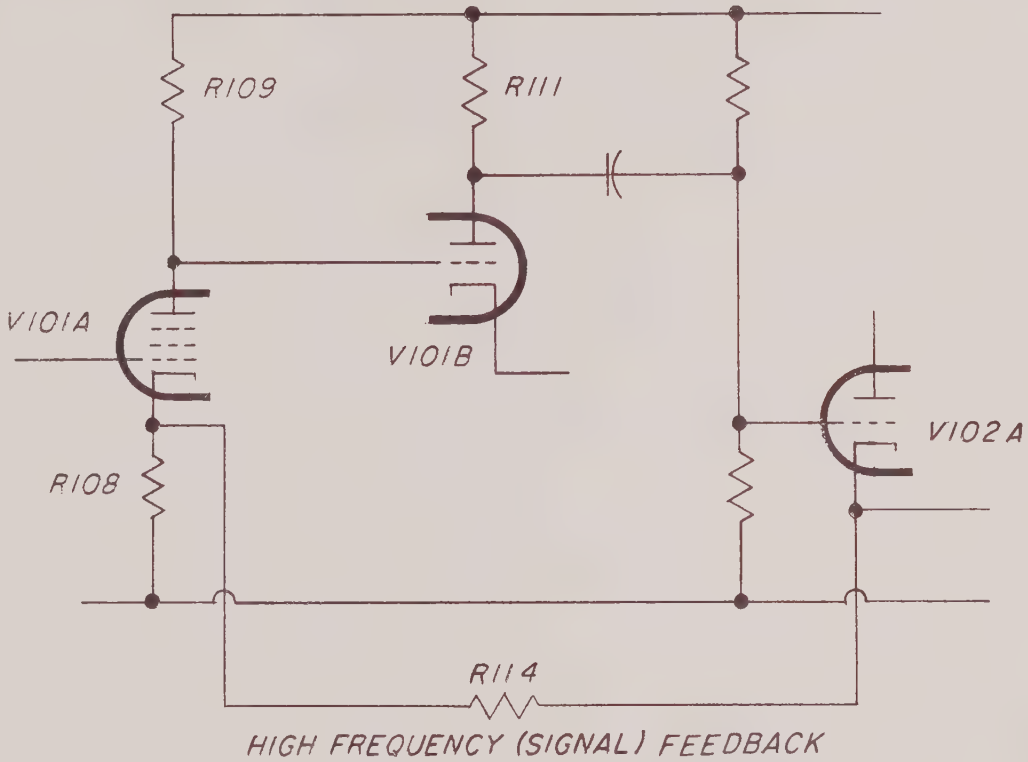
This circuit is nearly identical with the A1D amplifier discriminator of Bell and Jordan.

4-8. POWER SUPPLY

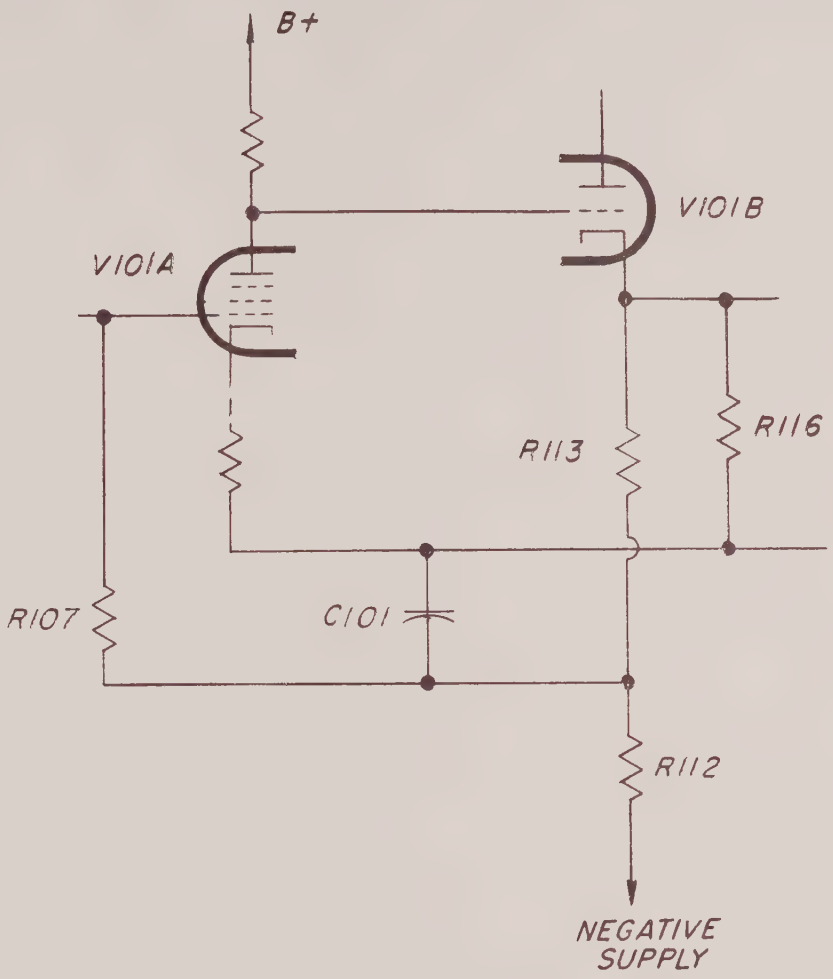
The unregulated B+ of 390V at the output of the filter section, C131, L101, and C132, is applied to the plates of the series regulator tube, V113. V114 in conjunction with the cold cathode regulator tube, V115, provides electronic regulation. The output voltage at full load (160 ma) is 270V, the rms ripple is 20mv.



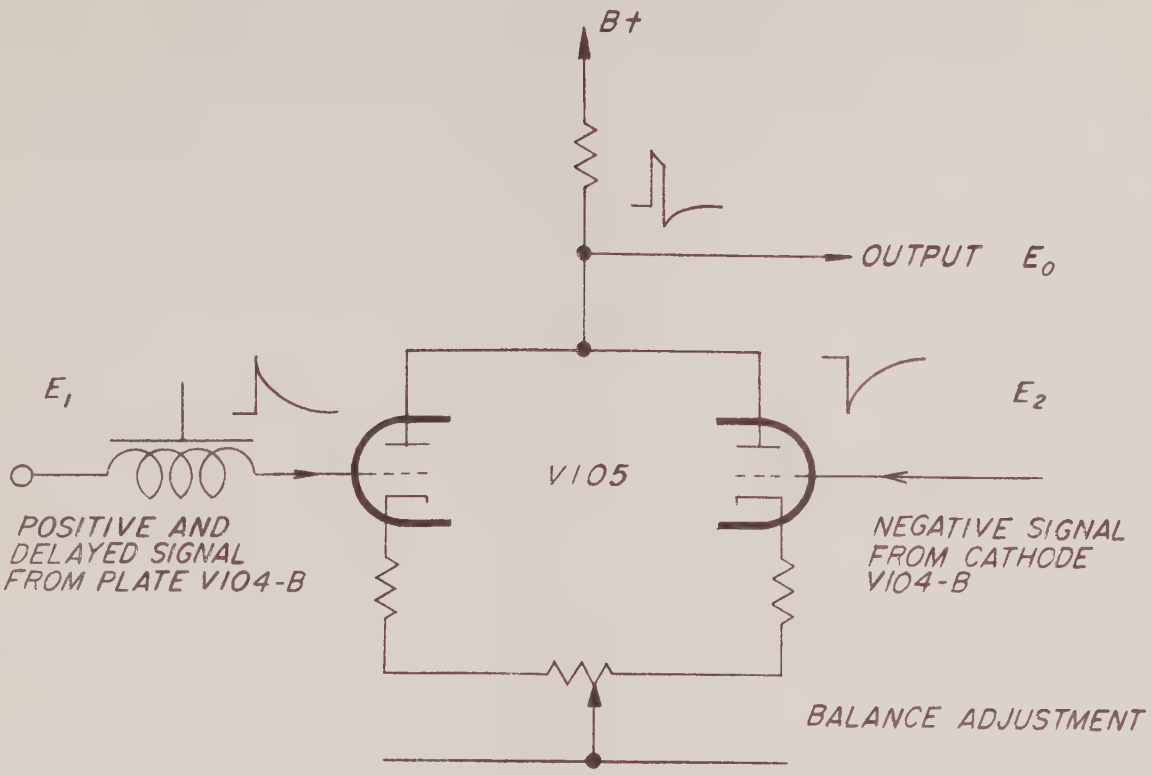
BLOCK DIAGRAM AMPLIFIER CIRCUIT
WAVEFORMS MODEL 215
FIGURE 4-1



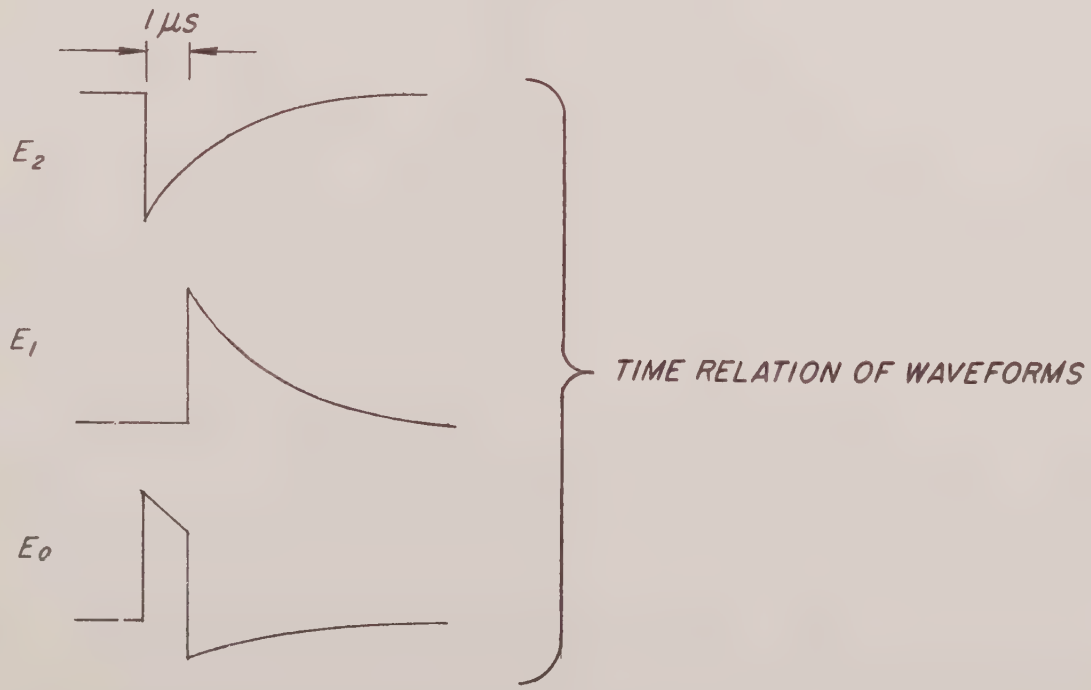
BASIC SIGNAL PATH 1ST AMPLIFIER
V101 & V102
FIGURE 4-2

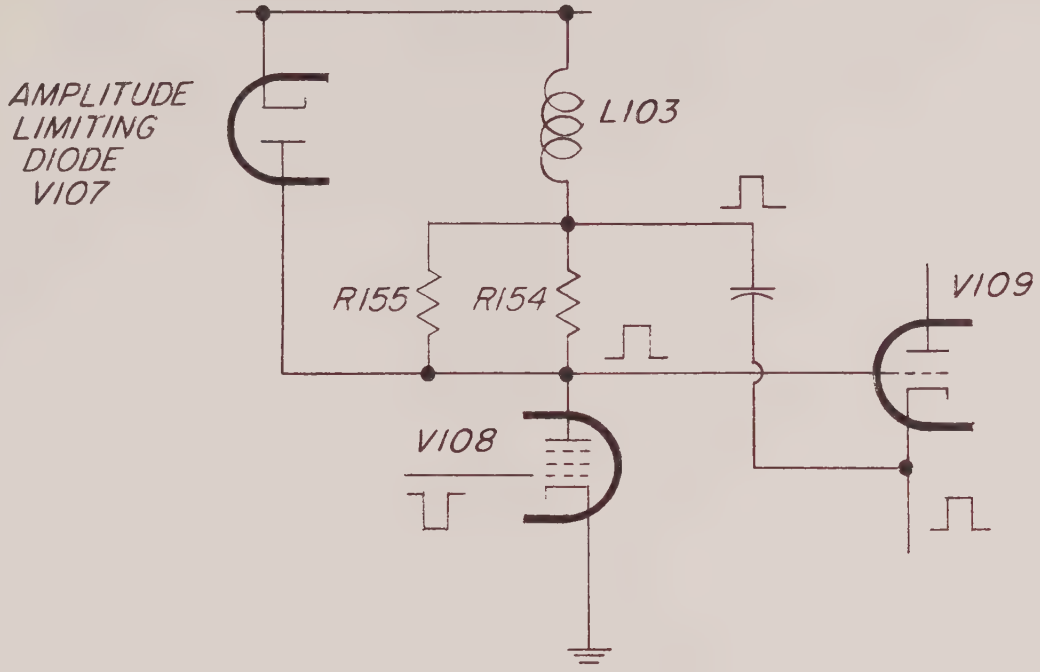


STABILIZING FEEDBACK NETWORK 1ST, (2ND)
AMPLIFIER
FIGURE 4-3



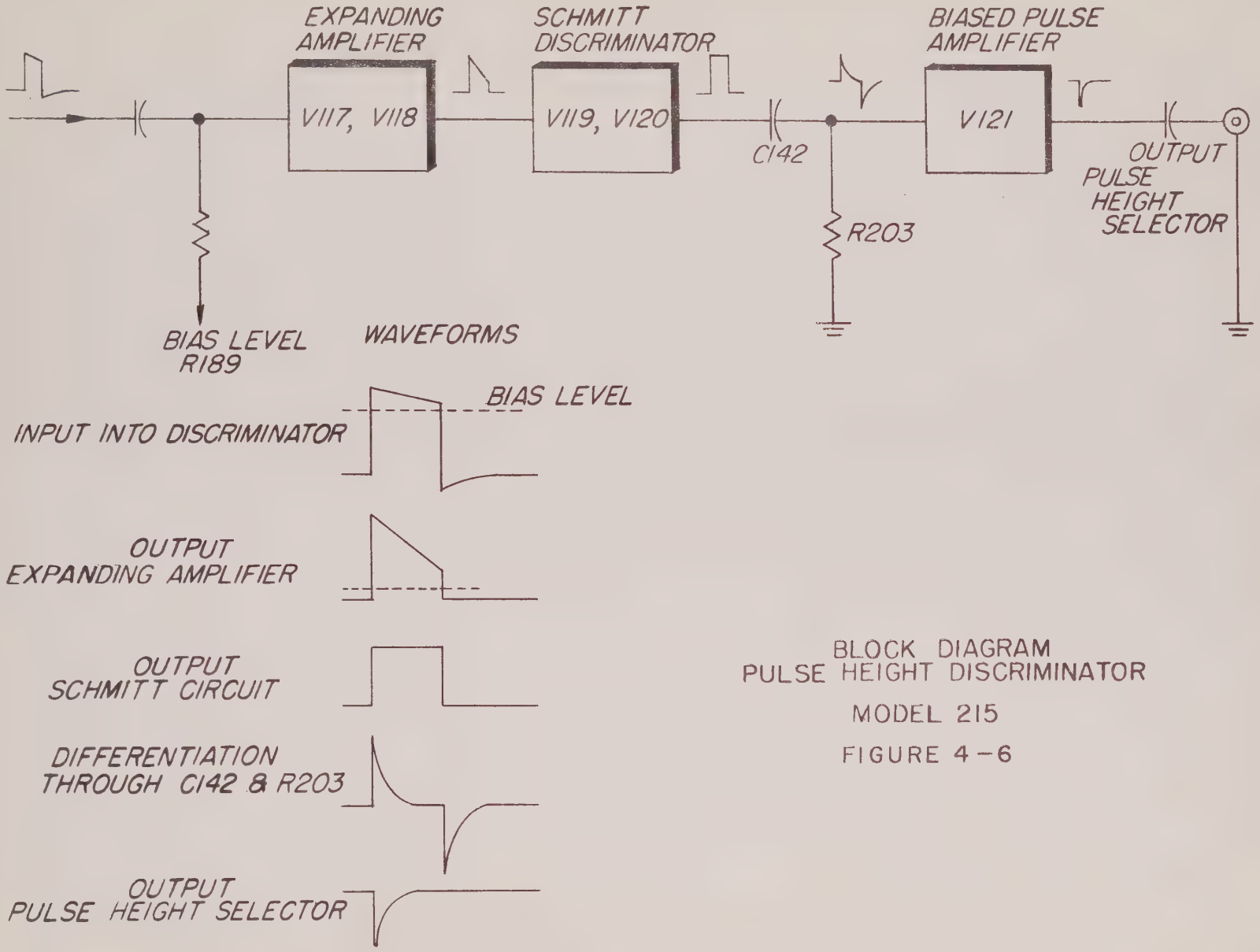
PULSE SHAPING & ADDER CIRCUIT
FIGURE 4-4





POSITIVE FEEDBACK (BOOTSTRAP)
OF HIGH LEVEL AMPLIFIER STAGE

FIGURE 4-5



BLOCK DIAGRAM
PULSE HEIGHT DISCRIMINATOR

MODEL 215

FIGURE 4-6

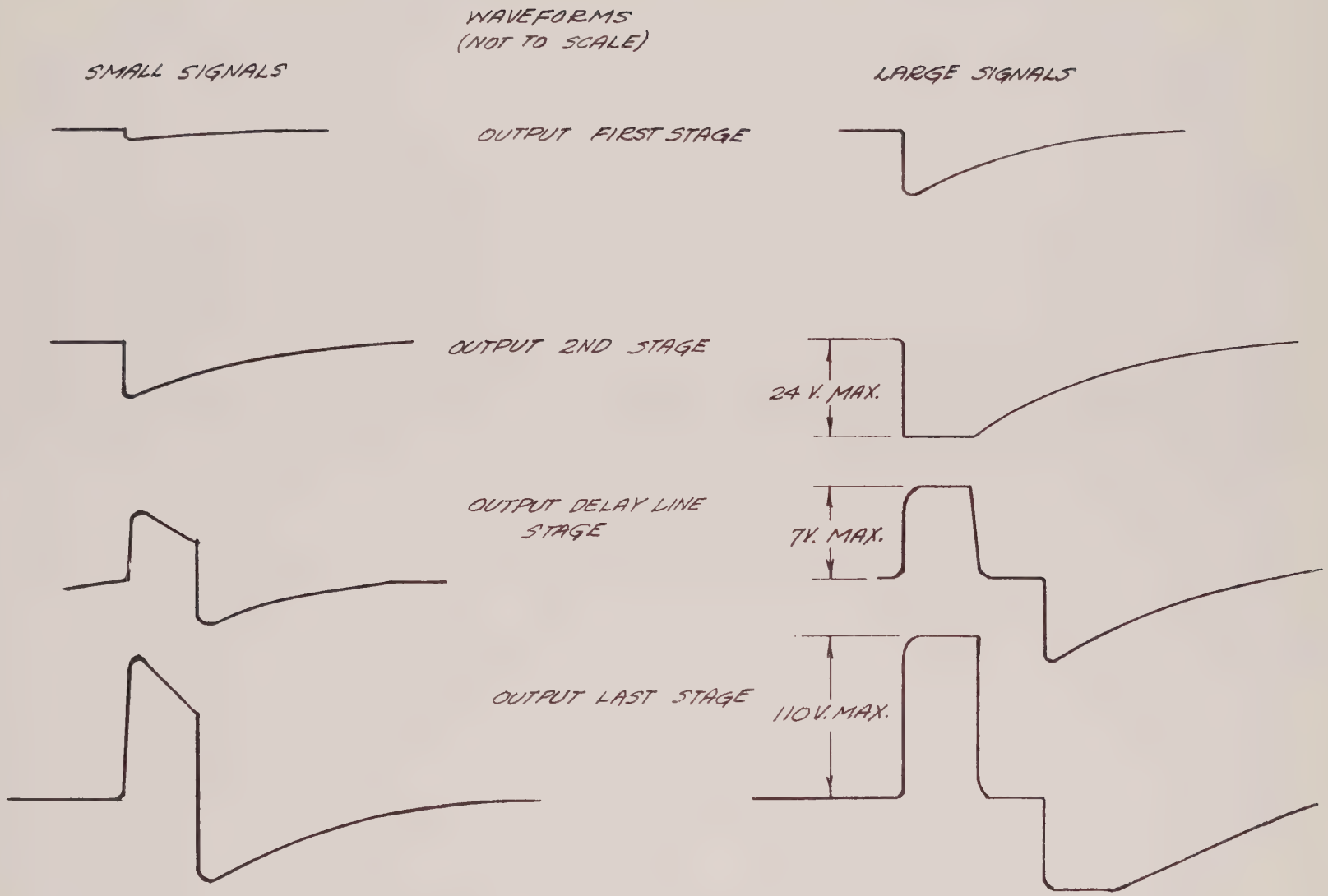
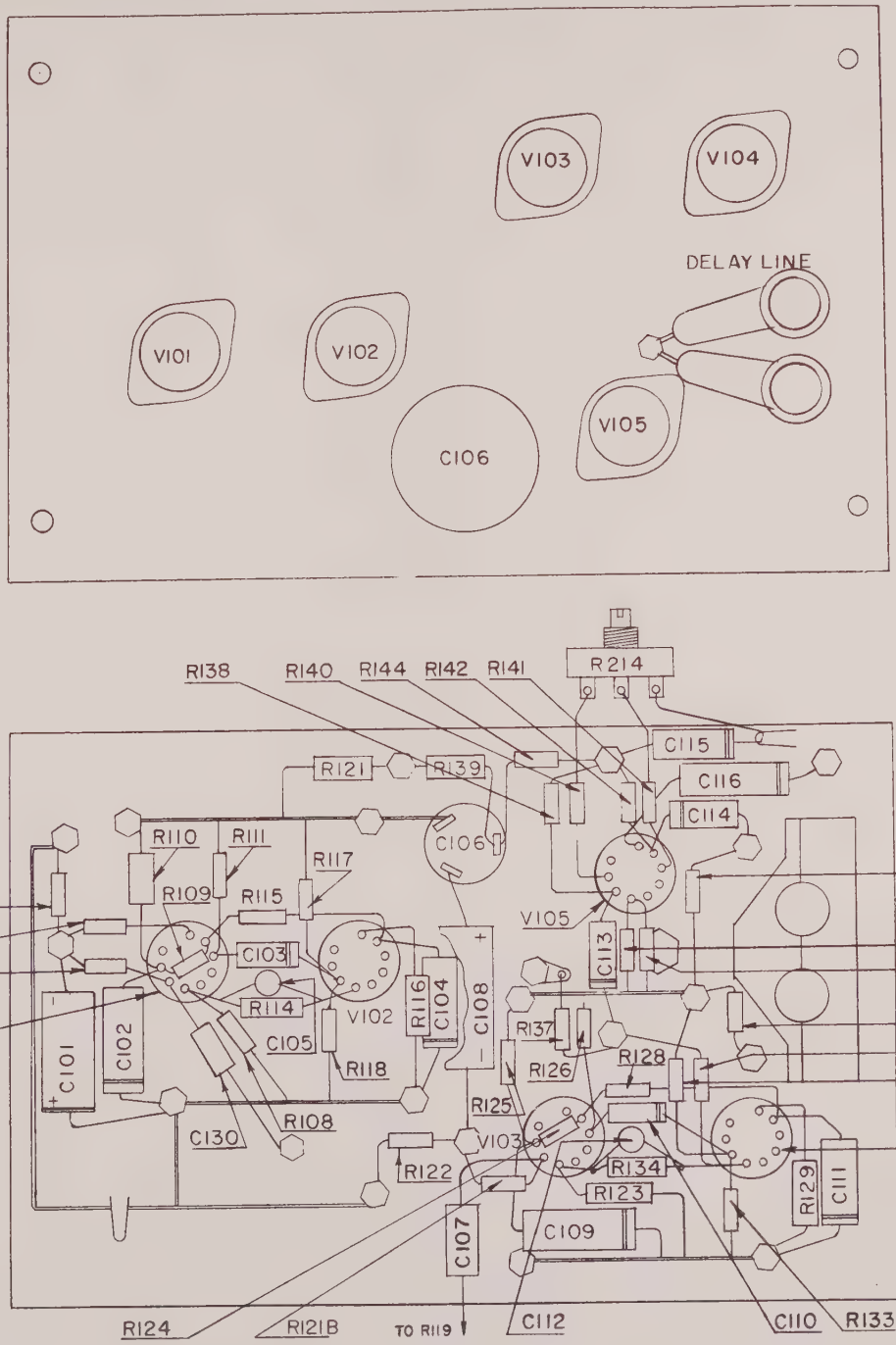

WAVEFORMS
(NOT TO SCALE)
SMALL SIGNALS
LARGE SIGNALS
OUTPUT FIRST STAGE
OUTPUT 2ND STAGE
24 V. MAX.
OUTPUT DELAY LINE
STAGE
7V. MAX.
OUTPUT LAST STAGE
110 V. MAX.

FIGURE 4-7

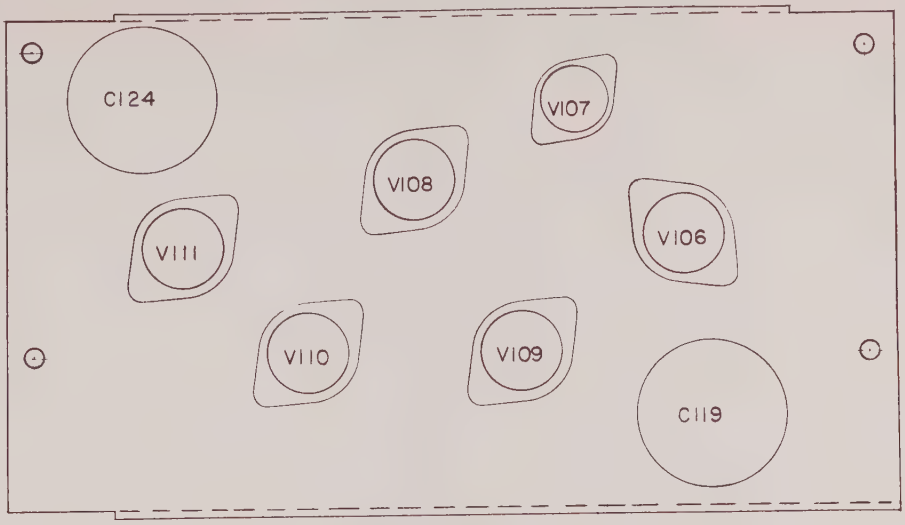
COMPONENT LOCATION AMPLIFIER SECTION I MODEL 215

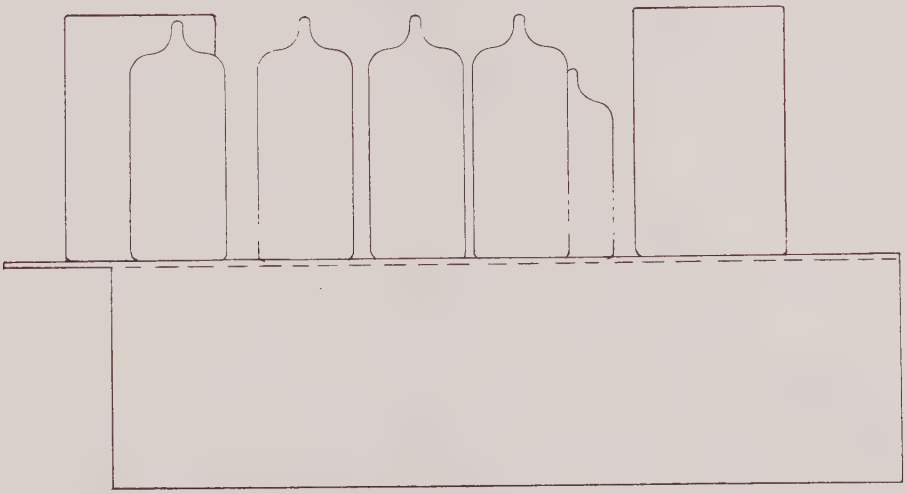


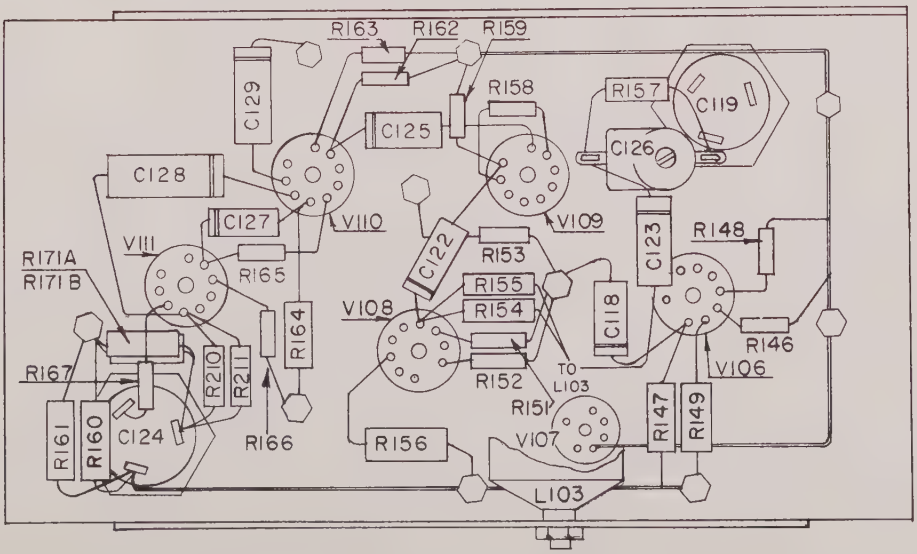
NOTE: ALL INTERCONNECTION WIRING NOT SHOWN, CONSULT SCHEMATIC D215-1 FOR ADDITIONAL CONNECTIONS

FIGURE 5-1 SHEET 1

COMPONENT LOCATION AMPLIFIER SECTION 2 MODEL 215

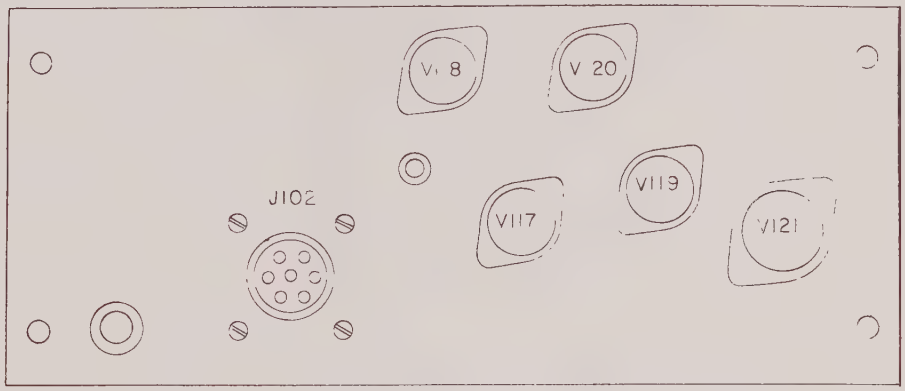


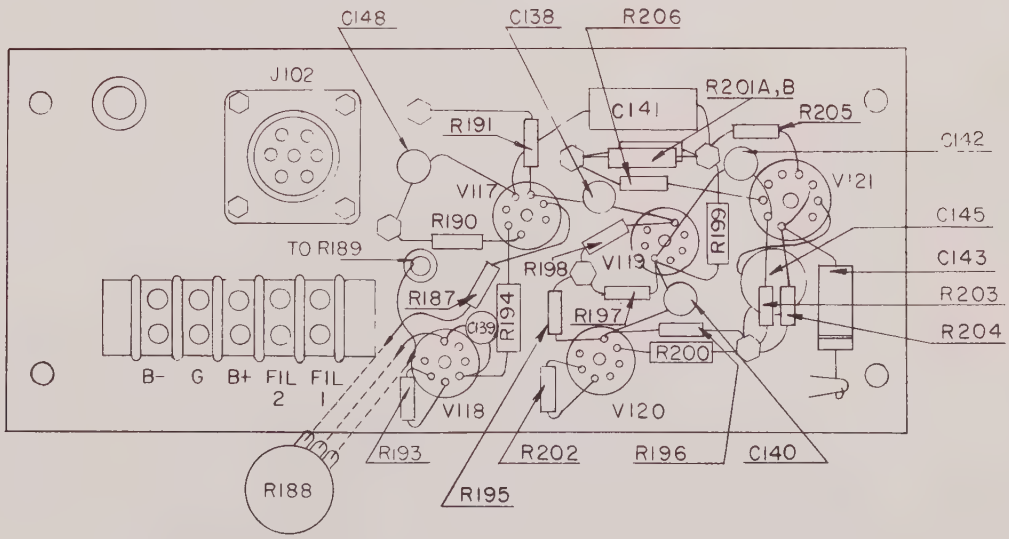




NOTE
ALL INTERCONNECTION WIRING NOT SHOWN CONSULT SCHEMATIC D215-1 FOR ADDITIONAL CONNECTIONS.

FIGURE 5-1 SHEET 2

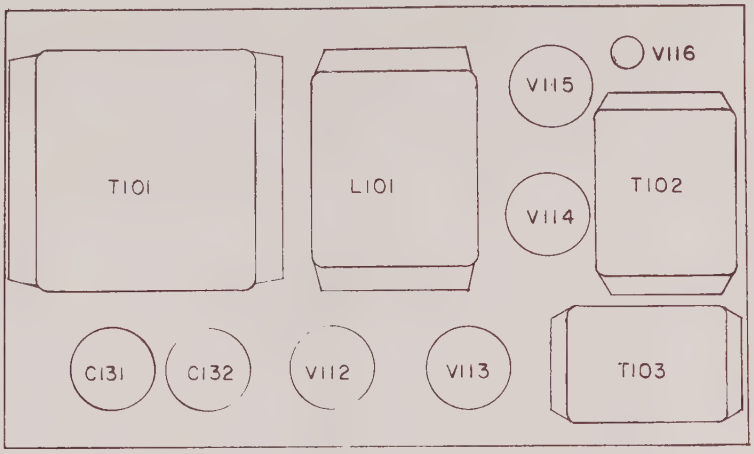


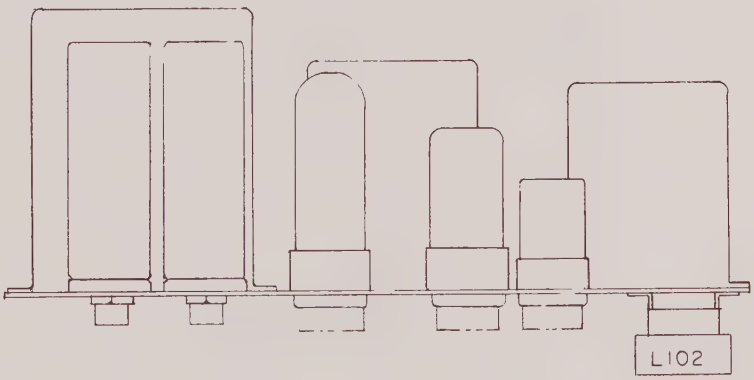


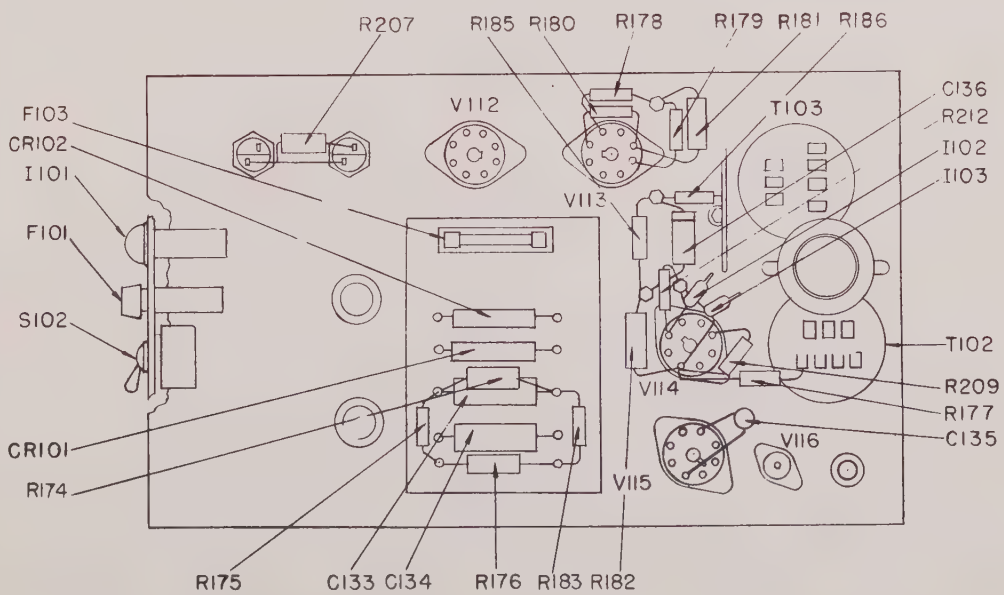
NOTE : ALL INTERCONNECTION WIRING NOT SHOWN, CONSULT SCHEMATIC D215-1 FOR ADDITIONAL CONNECTIONS

FIGURE 5-1 SHEET 3

COMPONENT LOCATION POWER SUPPLY MODEL 215







NOTE: ALL INTERCONNECTION WIRING NOT SHOWN,
CONSULT SCHEMATIC D215-1 FOR ADDITIONAL CONNECTIONS

FIGURE 5-1 SHEET 4

VOLTAGE & RESISTANCE MEASUREMENTS

"V" NO. & TYPE	TUBE PIN NUMBER								
	1	2	3	4	5	6	7	8	9
V101	75	72	200	6.3AC	0	1.3	-2.2	100	72
6AU8	13K	20K	20K	HT.	0	82Ω	220K	16K	21K
V102	75	72	240	6.3AC	0	17	10	240	240
6AU8	13K	220K	0	HT.	0	1.6K	90K	0	0
V103	75	72	200	6.3AC	0	1.6	-1.5	100	72
6AU8	13K	20K	20K	HT.	0	100Ω	100K	16K	21K
V104	75	72	240	6.3AC	0	24	18	220	220
6AU8	13K	220K	0	HT.	0	1.8K	180K	1.2K	1.2K
V105	180	13	16	6.3AC	0	180	13	16	0
6BZ7	2.2K	220K	2.2K	HT.	0	2.2K	220K	2.2K	0
V106	NC	NC	NC	6.3AC	0	1.6	0	80	100
6AU8	/	/	/	HT.	0	100Ω	5.1K	56K	13K
V107	240	120	6.3AC	0	240	NC	120		
6AL5	0	7.5K	/	0	/	/	7.5K		
V108	0	-4.4	150	6.3AC	0	120	0	150	-4.4
6CL6 6197	0	3K	18K	HT.	0	7K	0	18K	3K
V109	20	12	240	6.3AC	0	240	20	240	12
6CL6 6197	0	110K	0	HT	0	0	0	0	110K

TABLE 5-2, SHEET 1

VOLTAGE & RESISTANCE MEASUREMENTS (CONT.)

"V" NO. & TYPE	TUBE PIN NO'S.								
	1	2	3	4	5	6	7	8	9
V110	8.0	0	200	6.3AC	0	200	7	200	0
6197	2.2K	51K	0	HT.	0	2.2K	0	/	/
V111	6.5	0	200	6.3AC	0	80	6.5	200	0
6197	270Ω	220K	100Ω	HT.	0	7K	270Ω	/	/
V112	NC	390	NC	385AC	NC	385AC	NC	390	
5U4GA	/	HT.	/	40Ω	/	40Ω	/	HT.	/
V113	230	370	270	230	370	270	6.3AC 150DC	150	
6080	0	82Ω	0	/	82Ω	0	HT	HT	
V114		0	0	-5	0	150	6.3AC 0	230	
6AC7		HT.	0	82K	0	30K	HT.	25K	
V115	NC	0	NC	NC	150	NC	NC		
OD3	/	0	/	/	/	/	/		
V116	0	-85	0	-85	0	NC	-85		
85A2	0	50K	0		0	/	50K		
V117	VAR	100	6.3AC	0	260	260	100		
6AK5	1M	24K	HT.	0	6.8K	0	24K		
V118	95	100	6.3AC	0	260	260	100		
6AK5	82K	24K	HT.	0	0	100Ω	24K		

TABLE 5-2, SHEET 2

VOLTAGE & RESISTANCE MEASUREMENTS (CONT.)

"V" NO. & TYPE	TUBE PIN NO'S								
	1	2	3	4	5	6	7	8	9
V119	36	38	6.3AC	0	100	120	38		
6AK5	600K	4.7K	HT.	0	15K	12K	4.7K		
V120	30	37	6.3AC	0	120	120	37		
6AK5	56K	4.7K	HT.	0	15K	15K	4.7K		
V121	5.4	0	125	6.3AC	0	110	5.4	125	0
6197 6CL6	2.2K	4.7K	20K	HT.	0	3.3K	2.2K	20K	4.7K

NOTE: RESISTANCE READINGS OBTAINED WITH POWER OFF AND B+ OF MEASURED SECTION SHORTED TO GROUND IN ORDER TO AVOID CHARGING DECOUPLING CAPACITOR WHILE MEASURING WITH OHMMETER.

TABLE 5-2, SHEET 3

APPENDIX

Pulse Shaping by "Double Differentiation" in the Model 215 Non-Overloading Amplifier

In order to operate the Model 215 Amplifier at its optimum performance, it is necessary to have perfect balance adjustment (by means of R214 as shown in Schematic 215-1). A short review of the design principles of this type of pulse shaping might be helpful.

The input pulse is assumed to have a fast rise time (for NaI scintillation crystals in the order of 0.25μsec) and a long decay time constant T_1 of 200μsec. This input pulse (of negative polarity) is applied to the RC network comprising C146 and the precision resistors R101 through R106. The "differentiating" time constant of this network, T_2, is 1.6μsec.

Using Laplace transform notation and assuming for ease of calculation a negligibly fast rise time of the test pulse, we arrive at the expression for the pulse into V101A:

$$F(s) = \frac{1}{s} \cdot \frac{T_1 s}{(T_1 s + 1)} \cdot \frac{T_2 s}{(T_2 s + 1)} \qquad 1a)$$

$$T_1 = 2 \times 10^{-4} \text{ sec}$$
$$T_2 = 1.6 \times 10^{-6} \text{ sec}$$

$$f(t) = \frac{e^{-t/T_1}}{\left(\frac{T_1}{T_2} - 1\right)} + \frac{e^{-t/T_2}}{\left(\frac{T_2}{T_1} - 1\right)} \qquad 1b)$$

Furthermore, we assume that the feedback amplifiers have infinite bandwidth and a gain of one. The overshoot on the basis of these two time constants can be found by setting the first derivative of expression 1b) equal to zero. In this way we find the time t_m at which the maximum overshoot occurs to be:

$$t_m = 2 \ln \frac{T_1}{T_2} \cdot \left(\frac{1}{\frac{1}{T_2} - \frac{1}{T_1}} \right) \qquad 2$$

For a large ratio of T_1/T_2 we can use the approximation

$$t_m = T_2 \cdot 2 \ln \alpha \qquad \alpha = T_1/T_2$$

Substituting this expression back into 1b) gives us the magnitude of the overshoot (See Fig 1) as:

$$f(t)_{max} = \frac{1}{\alpha} e^{-\frac{2\ln\alpha}{\alpha}} - e^{-2\ln\alpha} \qquad 3)$$

For $\alpha \approx 100$ this amounts to $f(t)_{max} = .91\%$

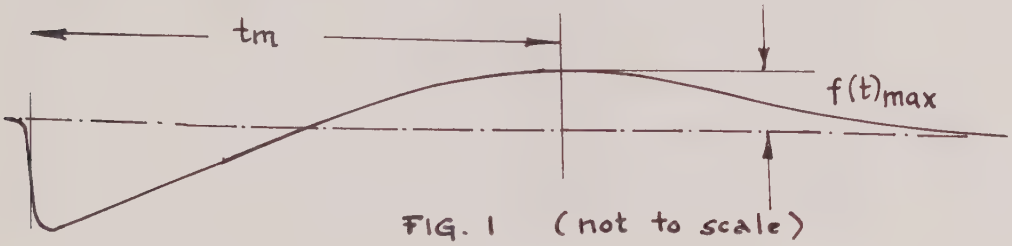


FIG. 1 (not to scale)

The second differentiation is achieved by means of an adder circuit which combines the negative output from V104B and the delayed positive output from the plate of the same tube. (See Fig. IV, 4 of the Instruction Manual.)

The output is given by $$e_o(t) = e_1(t) - e_2(t - t_d) \qquad 4)$$

where t_d refers to the electrical length of the delay line. If we assume $t_d/T \ll 1$ we have at perfect balance ($E_1 = E_2 = E_{1n}$)

$$e_o(t) = E_{in} \, t_d/T_1 \, e^{-t/T_1}$$

Therefore the transfer ratio e_o/e_i is proportional to the ratio t_d/T_1. For sinusoidal input (say 60 cps noise) the relation is

$$e_o(t) = E_1 \sin\omega t - E_2 \sin\omega(t - t_d)$$

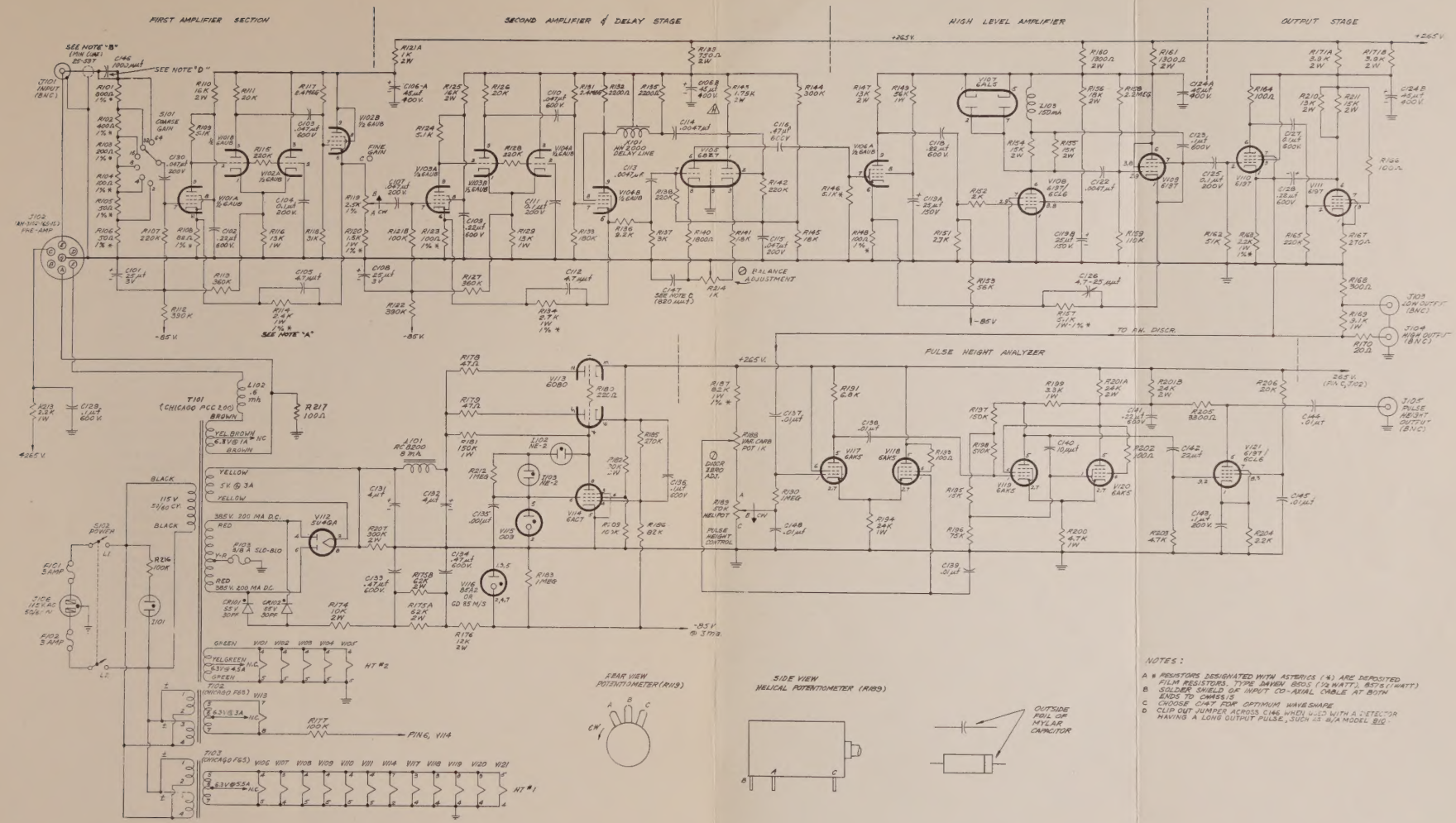
setting $E_1 \approx E_2$; $t_1 \to 0$ we find

$$e_o(t) \cong (E_1 - E_2)\,\omega t + E_2 \omega t_d$$

We see that for perfect balance the transfer ratio is proportional to E_{1n}, the

frequency, and the time delay. For small unbalance we can neglect the term $E_2 \omega t_d$ and find the transfer ratio to be proportional to the unbalance and the frequency.

Using the values of the Model 215 Amplifier and $\omega = 120\pi$, $t = 1\mu sec$, this ratio is 3.77×10^{-4}. The peak amplitude under slight unbalance condition can be approximated by $e_o = E_1 - E_2$. Therefore, any unbalance will affect the transfer ratio linearly. In order to get an estimate on how critical the adjustment is, we find that 7 degrees rotation of the balancing potentiometer corresponds to 1% unbalance (transfer ratio 0.01). One possible way of balancing the adder circuit is to minimize the 60 cps components of the output. This can be done with the help of an oscilloscope.



NOTES:

A * RESISTORS DESIGNATED WITH ASTERICS (*) ARE DEPOSITED FILM RESISTORS. TYPE DAVEN ERDS (1/2 WATT), RST-5 (1 WATT)

B SOLDER SHIELD OF INPUT CO-AXIAL CABLE AT BOTH ENDS TO CHASSIS

C CHOOSE CHART FOR OPTIMUM WAVESHAPE

D CLIP OUT JUMPER ACROSS C146 WHEN USED WITH A DETECTOR HAVING A LONG OUTPUT PULSE, SUCH AS B/A MODEL BIC

NOTE:

Schematic separately enclosed supersedes this if a later revision is indicated.

SCHEMATIC
NON-OVERLOADING LINEAR AMPLIFIER
50/60~115V MODEL 215 BASIC

REV
U

WARRANTY

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